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TECHNICAL NOTE No. 1041

A Drag Coefficient, K_D, Based On The 8-Inch Howitzer Shell, HE, M106

C. T. ODOM

DEPARTMENT OF THE ARMY PROJECT No. 5B0307003
ORDNANCE RESEARCH AND DEVELOPMENT PROJECT No. TB3-0430

BALLISTIC RESEARCH LABORATORIES

ABERDEEN PROVING GROUND, MARYLAND

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October 1955

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A Drag Coefficient, K_D, Based on the 8-Inch Howitzer Shell, HE, M106

During December 1949 and January 1950, twelve rounds of 8-Inch Howitzer Shell, HE, M106 (See Figure 1.) were fired at high angles of elevation to determine the mean drag of the round. Radio doppler measurements of radial velocity along each trajectory were made with the Model 10 Velocimeter. To cover a large portion of the velocity history of each round, high angles of elevation were fired. The doppler records were measured and reduced by R. B. Patton.*

The first fit of the mean drag data of the twelve rounds was made informally by the Surveillance Laboratory (now the Surveillance Branch) with two hyperbolas. Application of this fit to full scale range firing data indicated that improvement could be made by joining the two hyperbolas in the transonic region with a cubic polynomial and by replacing the subsonic portion of the function with a constant.

Finally the improved fit was adjusted by a constant to produce a weighted-mean over-all form factor of unity with respect to the full scale range firing data. This adjusted fit will be used for firing table computations unless the results of additional range firings now being planned indicate that further modifications and adjustments are desirable.

The fitting expressions, which at each juncture point give similar values of the K_D's and their first derivatives, are tabulated below:

In the Interval	K_D is given by
$0 \leq M \leq 0.71627$	0.0509362061
$0.71627 \leq M \leq 0.76104$	$4.521434552M^3 - 10.42261884M^2 + 7.971751250M - 1.973265092$
$0.76104 \leq M \leq 0.93116$	$-0.5675865634 + 0.6627785038M + \sqrt{0.4955008785M^2 - 0.9122953214M + 0.4201021171}$
$0.93116 \leq M \leq 0.94906$	$191.81088075M^3 - 532.7070287?M^2 + 494.13979376M - 153.03230004$
$0.94906 \leq M \leq 3$	$-0.4953449066 + 0.6585549046M - \sqrt{0.5014967518M^2 - 1.0090404772M + 0.5079263485}$

*Patton, R.B., "Determination of Drag Functions for 8" Howitzer Shell HE, M106" BRL Technical Note No. 392, March 1951.

Charles T. Odom

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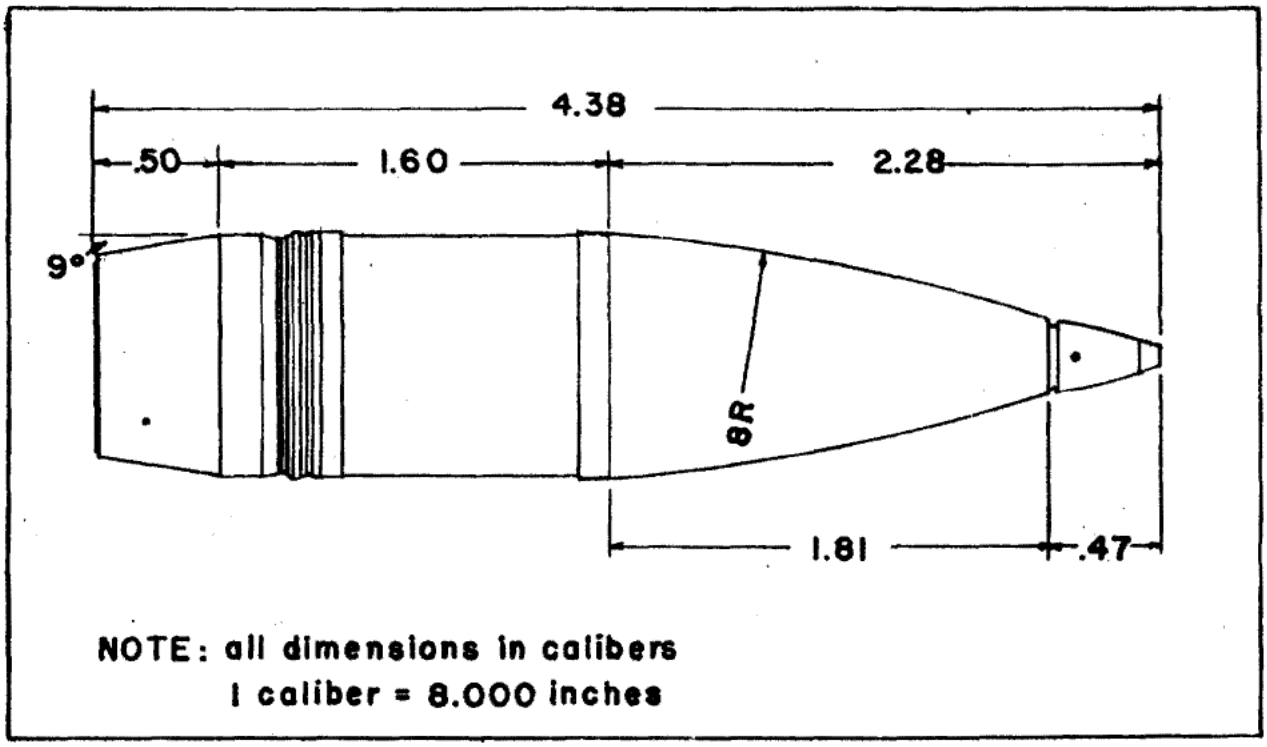

FIG. 1. SHELL, 8-INCH, HE, M106 WITH FUZE, PD, M51A4

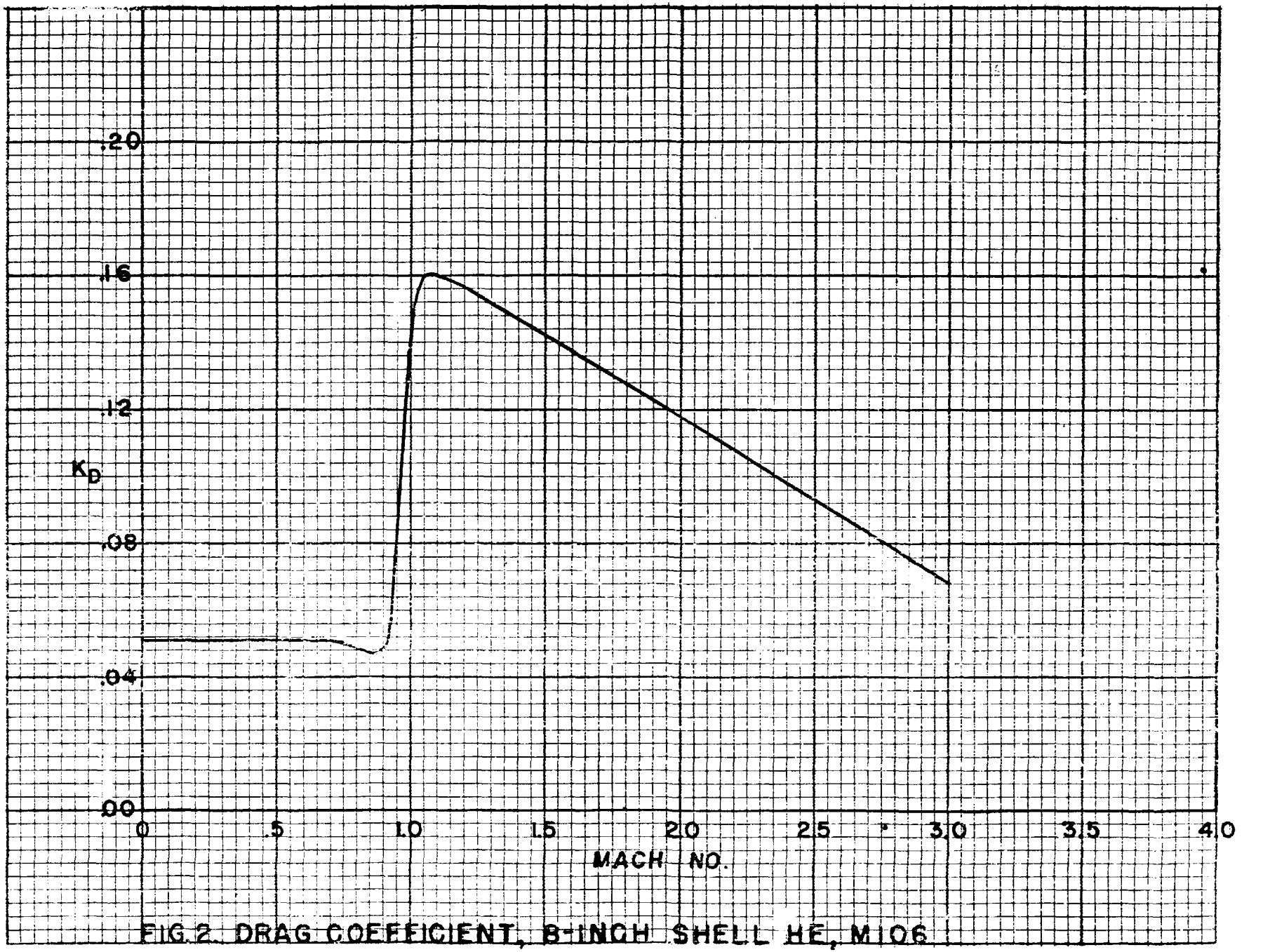

FIG. 2. DRAG COEFFICIENT, 8-INCH SHELL HE, M106

TABLE
of
DRAG COEFFICIENTS

Drag Coefficient 8-Inch, HE, M106

M	K_D	M	K_D	M	K_D	M	K_D
3.000	.068132	2.600	.087943	2.200	.107733	1.800	.127468
2.990	.068627	2.590	.088438	2.190	.108227	1.790	.127960
2.980	.069122	2.580	.088933	2.180	.108721	1.780	.128452
2.970	.069618	2.570	.089428	2.170	.109215	1.770	.128944
2.960	.070113	2.560	.089923	2.160	.109710	1.760	.129435
2.950	.070609	2.550	.090418	2.150	.110204	1.750	.129927
2.940	.071104	2.540	.090913	2.140	.110698	1.740	.130418
2.930	.071600	2.530	.091408	2.130	.111192	1.730	.130909
2.920	.072095	2.520	.091903	2.120	.111686	1.720	.131400
2.910	.072590	2.510	.092398	2.110	.112180	1.710	.131891
2.900	.073086	2.500	.092893	2.100	.112674	1.700	.132382
2.890	.073581	2.490	.093388	2.090	.113168	1.690	.132873
2.880	.074076	2.480	.093883	2.080	.113662	1.680	.133363
2.870	.074572	2.470	.094378	2.070	.114156	1.670	.133854
2.860	.075067	2.460	.094873	2.060	.114649	1.660	.134344
2.850	.075562	2.450	.095368	2.050	.115143	1.650	.134834
2.840	.076058	2.440	.095862	2.040	.115637	1.640	.135324
2.830	.076553	2.430	.096357	2.030	.116131	1.630	.135813
2.820	.077048	2.420	.096852	2.020	.116624	1.620	.136303
2.810	.077544	2.410	.097347	2.010	.117118	1.610	.136792
2.800	.078039	2.400	.097842	2.000	.117611	1.600	.137281
2.790	.078534	2.390	.098336	1.990	.118105	1.590	.137770
2.780	.079030	2.380	.098831	1.980	.118598	1.580	.138258
2.770	.079525	2.370	.099326	1.970	.119091	1.570	.138746
2.760	.080020	2.360	.099821	1.960	.119585	1.560	.139234
2.750	.080515	2.350	.100315	1.950	.120078	1.550	.139722
2.740	.081011	2.340	.100810	1.940	.120571	1.540	.140209
2.730	.081506	2.330	.101305	1.930	.121064	1.530	.140696
2.720	.082001	2.320	.101799	1.920	.121557	1.520	.141182
2.710	.082496	2.310	.102294	1.910	.122050	1.510	.141669
2.700	.082992	2.300	.102788	1.900	.122543	1.500	.142154
2.690	.083487	2.290	.103283	1.890	.123036	1.490	.142640
2.680	.083982	2.280	.103777	1.880	.123529	1.480	.143125
2.670	.084477	2.270	.104272	1.870	.124022	1.470	.143609
2.660	.084972	2.260	.104766	1.860	.124514	1.460	.144093
2.650	.085467	2.250	.105261	1.850	.125007	1.450	.144576
2.640	.085963	2.240	.105755	1.840	.125499	1.440	.145059
2.630	.086458	2.230	.106250	1.830	.125991	1.430	.145541
2.620	.086953	2.220	.106744	1.820	.126484	1.420	.146023
2.610	.087448	2.210	.107238	1.810	.126976	1.410	.146503
2.600	.087943	2.200	.107733	1.800	.127468	1.400	.146983

Drag Coefficient 8-Inch, HE, M106

M	K_D
1.400	.146983
1.390	.147463
1.380	.147941
1.370	.148418
1.360	.148894
1.350	.149369
1.340	.149843
1.330	.150316
1.320	.150787
1.310	.151256
1.300	.151723
1.290	.152189
1.280	.152652
1.270	.153113
1.260	.153571
1.250	.154026
1.240	.154477
1.230	.154925
1.220	.155368
1.210	.155806
1.200	.156238
1.199	.156280
1.198	.156323
1.197	.156366
1.196	.156408
1.195	.156451
1.194	.156493
1.193	.156536
1.192	.156578
1.191	.156620
1.190	.156663
1.189	.156705
1.188	.156747
1.187	.156789
1.186	.156830
1.185	.156872
1.184	.156914
1.183	.156955
1.182	.156997
1.181	.157038
1.180	.157080

M	K_D
1.180	.157080
1.179	.157121
1.178	.157162
1.177	.157203
1.176	.157244
1.175	.157285
1.174	.157325
1.173	.157366
1.172	.157407
1.171	.157447
1.170	.157487
1.169	.157527
1.168	.157567
1.167	.157607
1.166	.157647
1.165	.157687
1.164	.157727
1.163	.157766
1.162	.157805
1.161	.157845
1.160	.157884
1.159	.157923
1.158	.157961
1.157	.158000
1.156	.158038
1.155	.158077
1.154	.158115
1.153	.158153
1.152	.158191
1.151	.158229
1.150	.158266
1.149	.158304
1.148	.158341
1.147	.158378
1.146	.158415
1.145	.158452
1.144	.158488
1.143	.158525
1.142	.158561
1.141	.158597
1.140	.158633

M	K_D
1.140	.158633
1.139	.158668
1.138	.158704
1.137	.158739
1.136	.158774
1.135	.158809
1.134	.158843
1.133	.158877
1.132	.158911
1.131	.158945
1.130	.158979
1.129	.159012
1.128	.159045
1.127	.159078
1.126	.159111
1.125	.159143
1.124	.159175
1.123	.159206
1.122	.159238
1.121	.159269
1.120	.159300
1.119	.159330
1.118	.159360
1.117	.159390
1.116	.159419
1.115	.159448
1.114	.159477
1.113	.159505
1.112	.159533
1.111	.159561
1.110	.159588
1.109	.159615
1.108	.159641
1.107	.159667
1.106	.159692
1.105	.159717
1.104	.159742
1.103	.159766
1.102	.159789
1.101	.159812
1.100	.159835

M	K_D
1.100	.159835
1.099	.159857
1.098	.159878
1.097	.159899
1.096	.159919
1.095	.159938
1.094	.159957
1.093	.159975
1.092	.159993
1.091	.160010
1.090	.160026
1.089	.160041
1.088	.160056
1.087	.160069
1.086	.160082
1.085	.160094
1.084	.160106
1.083	.160116
1.082	.160125
1.081	.160134
1.080	.160141
1.079	.160147
1.078	.160152
1.077	.160156
1.076	.160159
1.075	.160161
1.074	.160161
1.073	.160160
1.072	.160158
1.071	.160154
1.070	.160149
1.069	.160142
1.068	.160134
1.067	.160124
1.066	.160112
1.065	.160099
1.064	.160083
1.063	.160066
1.062	.160046
1.061	.160025
1.060	.160001

Drag Coefficient 8-Inch, HE, M106

M	K_D
1.060	.160001
1.059	.159975
1.058	.159946
1.057	.159915
1.056	.159881
1.055	.159844
1.054	.159805
1.053	.159762
1.052	.159716
1.051	.159667
1.050	.159614
1.049	.159557
1.048	.159496
1.047	.159431
1.046	.159362
1.045	.159288
1.044	.159210
1.043	.159126
1.042	.159037
1.041	.158942
1.040	.158842
1.039	.158735
1.038	.158621
1.037	.158500
1.036	.158372
1.035	.158236
1.034	.158092
1.033	.157939
1.032	.157776
1.031	.157604
1.030	.157421
1.029	.157228
1.028	.157023
1.027	.156805
1.026	.156575
1.025	.156331
1.024	.156073
1.023	.155799
1.022	.155510
1.021	.155204
1.020	.154880

M	K_D
1.020	.154880
1.019	.154538
1.018	.154177
1.017	.153796
1.016	.153394
1.015	.152970
1.014	.152524
1.013	.152054
1.012	.151561
1.011	.151043
1.010	.150500
1.009	.149932
1.008	.149338
1.007	.148718
1.006	.148072
1.005	.147400
1.004	.146701
1.003	.145976
1.002	.145226
1.001	.144450
1.000	.143649
.999	.142824
.998	.141975
.997	.141103
.996	.140208
.995	.139292
.994	.138355
.993	.137398
.992	.136422
.991	.135427
.990	.134415
.989	.133387
.988	.132342
.987	.131282
.986	.130208
.985	.129121
.984	.128020
.983	.126908
.982	.125783
.981	.124648
.980	.123503

M	K_D
.980	.123503
.979	.122348
.978	.121183
.977	.120010
.976	.118828
.975	.117639
.974	.116442
.973	.115238
.972	.114028
.971	.112811
.970	.111588
.969	.110360
.968	.109126
.967	.107887
.966	.106644
.965	.105396
.964	.104143
.963	.102886
.962	.101626
.961	.100361
.960	.099094
.959	.097822
.958	.096548
.957	.095270
.956	.093989
.955	.092706
.954	.091420
.953	.090131
.952	.088840
.951	.087547
.950	.086251
.949	.084954
.948	.083670
.947	.082412
.946	.081178
.945	.079967
.944	.078779
.943	.077612
.942	.076464
.941	.075335
.940	.074224

M	K_D
.940	.074224
.939	.073129
.938	.072050
.937	.070984
.936	.069931
.935	.068891
.934	.067861
.933	.066840
.932	.065828
.931	.064823
.930	.063827
.929	.062837
.928	.061946
.927	.061044
.926	.060073
925	.059096
.924	.058532
.923	.057763
.922	.057030
.921	.056334
.920	.055674
.919	.055051
.918	.054464
.917	.053913
.916	.053396
.915	.052914
.914	.052463
.913	.052044
.912	.051655
.911	.051293
.910	.050958
.909	.050647
.908	.050359
.907	.050093
.906	.049847
.905	.049619
.904	.049409
.903	.049214
.902	.049034
.901	.048868
.900	.048714

Drag Coefficient 8-Inch, HE, M106

M	K_D	M	K_D	M	K_D	M	K_D
.900	.048714	.860	.047131	.820	.047966	.780	.049253
.899	.048572	.859	.047140	.819	.047995	.779	.049288
.898	.048441	.858	.047150	.818	.048024	.778	.049323
.897	.048319	.857	.047160	.817	.048053	.777	.049358
.896	.048207	.856	.047172	.816	.048083	.776	.049393
.895	.048103	.855	.047184	.815	.048113	.775	.049428
.894	.048008	.854	.047197	.814	.048143	.774	.049463
.893	.047919	.853	.047212	.813	.048173	.773	.049498
.892	.047838	.852	.047226	.812	.048203	.772	.049533
.891	.047763	.851	.047242	.811	.048234	.771	.049569
.890	.407694	.850	.047258	.810	.048264	.770	.049604
.889	.047630	.849	.047275	.809	.048295	.769	.049640
.888	.047571	.848	.047292	.808	.048326	.768	.049675
.887	.047517	.847	.047310	.807	.048357	.767	.049711
.886	.047468	.846	.047329	.806	.048389	.766	.049747
.885	.047423	.845	.047348	.805	.048420	.765	.049783
.884	.047382	.844	.047368	.804	.048452	.764	.049818
.883	.047344	.843	.047388	.803	.048484	.763	.049854
.882	.047310	.842	.047409	.802	.048516	.762	.049890
.881	.047279	.841	.047431	.801	.048548	.761	.049926
.880	.047251	.840	.047452	.800	.048581	.760	.049962
.879	.047227	.839	.047475	.799	.048613	.759	.049998
.878	.047204	.838	.047497	.798	.048646	.758	.050034
.877	.047185	.837	.047520	.797	.048678	.757	.050069
.876	.047167	.836	.047544	.796	.048711	.756	.050104
.875	.047152	.835	.047568	.795	.048744	.755	.050138
.874	.047139	.834	.047592	.794	.048777	.754	.050173
.873	.047128	.833	.047617	.793	.048811	.753	.050207
.872	.047120	.832	.047642	.792	.048844	.752	.050240
.871	.047112	.831	.047667	.791	.048878	.751	.050273
.870	.047107	.830	.047693	.790	.048911	.750	.050305
.869	.047103	.829	.047719	.789	.048945	.749	.050337
.868	.047101	.828	.047745	.788	.048979	.748	.050369
.867	.047100	.827	.047772	.787	.049013	.747	.050400
.866	.047101	.826	.047799	.786	.049047	.746	.050430
.865	.047103	.825	.047826	.785	.049081	.745	.050460
.864	.047106	.824	.047854	.784	.049115	.744	.050489
.863	.047111	.823	.047881	.783	.049149	.743	.050517
.862	.047116	.822	.047910	.782	.049184	.742	.050545
.861	.047123	.821	.047938	.781	.049218	.741	.050572
.860	.047131	.820	.047966	.780	.049253	.740	.050599

Drag Coefficient 8-Inch, HE, M106

M	K_D
.740	.050599
.739	.050624
.738	.050649
.737	.050673
.736	.050696
.735	.050718
.734	.050739
.733	.050760
.732	.050779
.731	.050797
.730	.050815
.729	.050831
.728	.050846
.727	.050860
.726	.050873
.725	.050885
.724	.050896
.723	.050906
.722	.050914
.721	.050921
.720	.050927
.719	.050931
.718	.050934
.717	.050936
.716	.050936
.	.
.	.
.	.
.001	.050936
.000	.050936

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